Alberta Energy Regulator

Directive 020

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Well Abandonment

The Alberta Energy Regulator has approved this directive on March 15, 2018.

[*original signed by*]

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President and Chief Executive Officer

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1 Introduction

1.1 Purpose of the Directive

The Alberta Energy Regulator (AER) *Directive 020: Well Abandonment* details the minimum requirements for abandonments, casing removal, zonal abandonments, and plug backs as required under section 3.013 of the *Oil and Gas Conservation Rules*.

The objective of a well abandonment is to cover all nonsaline groundwater (water with total dissolved solids [TDS] less than 4000 milligrams per litre [mg/l]) and to isolate or cover all porous zones.

All open-hole and cased-hole abandonments must be conducted in accordance with the requirements in this directive.

1.2 AER Requirements

Following AER requirements is mandatory for the responsible duty holder as specified in legislation (e.g., licensee, operator, company, applicant, approval holder, or permit holder). The term "must" indicates a requirement, while terms such as "should," "recommends," and "expects" indicate a recommended practice. Information on compliance and enforcement can be found on the AER website.

The licensee must keep all test results and abandonment details for abandoned wells.

If a licence for an abandoned well is transferred, the new licensee assumes all responsibility for the control or further abandonment of the well and the responsibility for the costs of doing that work.

1.3 What's New in This Edition

In this edition of *Directive 020* all references to *Directive 019: Compliance Assurance*, which has been rescinded, and related information have been removed. In addition, references to the Energy Resources Conservation Board (ERCB) have been replaced with the AER.

1.4 Overview

When planning to abandon a well, a licensee has to determine whether the planned abandonment operation will be routine or nonroutine, as defined by this directive. A planned abandonment operation is **routine** if it meets all the requirements that apply to the well based on

- the type of well being abandoned,
- the well's geographic location,

- the impact of the well on any oil sands zones, and
- the absence of a wellbore problem.

Routine abandonments are any operations that comply with the requirements specified in this directive. **Routine** abandonment operations **do not** require AER approval before work is started. Nonroutine abandonments consist of any operations that vary from the requirements in this directive. **Nonroutine** abandonment operations **do** require AER approval before work is started.

Some examples of **nonroutine** abandonment operations are

- the abandonment of any well that is associated with a salt cavern;
- the abandonment of any well that is associated with an in situ coal gasification scheme;
- the planned abandonment of a well that has a wellbore problem, which includes
  - a fish-in-the-hole across two or more porous zones,
  - a leaking plug, or
  - a ghost hole across two or more porous zones;
- a reabandonment of a well;
- a planned surface abandonment of a well with flow remaining at surface;
- a planned surface abandonment of a well where cement does not cover all nonsaline groundwater zones;
- the planned use of cement plugs in a well in a manner that does not meet the requirements in this directive;
- the planned use of a bridge plug inside the surface casing;
- the planned use of any type of plugging device that will be set more than 15 metres (m) above the completion interval; and
- the planned removal of uncemented casing from the well in a manner that does not meet the requirements stated in this directive.

Note that the above is not a comprehensive list of the types of nonroutine abandonments.

This directive may not address every abandonment situation encountered in Alberta. If the licensee has questions about an abandonment operation, contact the AER at WellOperations@aer.ca *before* beginning any work. If an emergency situation occurs after hours or on a weekend, contact the appropriate AER field centre.

2 Requirements for Nonroutine Abandonment Requests and for Notification and Reporting

2.1 Obtaining Approval for Nonroutine Abandonment Operations

A nonroutine abandonment request must be submitted through the Digital Data Submission (DDS) system (AER > Submissions > Licence Abandonment > Non-routine Well Abandonment). In addition, an e-mail must be sent to the AER (WellOperations@aer.ca) that includes the application, all supporting documentation, and the wellbore schematic.

The AER will review the request and may ask the licensee to provide additional information regarding the nonroutine abandonment operation.

The licensee will be notified once the request has been approved or denied. The licensee must not begin operations prior to obtaining the approval and must conduct operations in accordance with the approval.

2.2 AER Notification

Notification is required prior to all open- and cased-hole well abandonment operations through the DDS system (AER > Notifications > Field Surveillance). Notification for open- and cased-hole abandonments (including zonal abandonment) must be submitted prior to commencement of operations.

Oil sands evaluation wells and test-hole wells drilled within the surface mineable area are exempt from the notification requirements.

2.3 AER Reporting Requirements

Surface abandonments must be reported through the DDS system (AER > Submissions > Licence Abandonment > Well Licence Abandonment) within 30 days of completing the operation.

Note that a well licence abandonment submission cannot be made if there is a casing failure or a surface casing/vent flow report that is open and/or outstanding for the well licence. The surface casing vent flow/gas migration reports and casing failure reports must have a resolution entered, and the reports must be closed within the DDS system (AER > Incidents) prior to the submission of the well licence abandonment information.

Plug logs must be submitted to the AER in accordance with *Directive 080: Well Logging* within 30 days of completing downhole operations. Refer to appendix 1.

Industry is responsible to ensure that all work performed on a well is properly reported. (See *Directive 059: Well Drilling and Completion Data Filing Requirements*.)

3 Previously Abandoned Wells/Zones

3.1 Previously Abandoned Wells (Cut and Capped)

Wells that were abandoned to the standards in place prior to this edition of *Directive 020* are not required to be reabandoned to current standards. Exceptions to this are leaking wells and wells that are being re-entered (see below).

3.2 Previous Zonal Abandonments

Active wells that have existing zonal abandonments and were compliant at the time of the zonal abandonment will not be required to be reabandoned to current standards. The exception to this is as follows.

For wells with existing zonal abandonments of level-A intervals (see appendix 1 for definition of a Level-A interval), an additional cement plug must be circulated on top of the uppermost previously abandoned zone. This cement plug must be a minimum length of 30 vertical metres and have a minimum volume of 1 m^3. The base of this plug must be located below the BGWP.

If the uppermost previously abandoned zone's plug is above the BGWP,

- the plug must be drilled out, and
- an additional cement plug must be circulated on top of the uppermost previously abandoned zone. This cement plug must be a minimum length of 30 vertical metres. All perforations above this point must be abandoned to the current standard.

3.3 Leaking Wells/Lowering Casing Stubs

The current licensee of the well must submit a nonroutine abandonment request to the AER (WellOperations@aer.ca) for approval (see section 2.1). The request must include the reason for the re-entry. The licensee must also notify the mineral rights owner(s) and have an active surface lease agreement. Approval from Alberta Energy is required if the mineral rights have reverted back to the Crown. Operations to re-enter the well for repair or lowering of the casing stub may proceed once the appropriate approvals are in place.

For wells and zones found to be leaking, the source of the leak must be identified and repaired in accordance with AER *Interim Directive (ID) 2003-01: 1) Isolation Packer Testing, Reporting, and Repair Requirements; 2) Surface Casing Vent Flow Gas Migration Testing, Reporting, and Repair Requirements; 3) Casing Failure Reporting and Repair Requirements*. The leaking zone and all those above must be abandoned in accordance with *Directive 020*. The well must be abandoned at surface immediately after confirmation that the repair has been successful. The updated licence abandonment must be submitted through the DDS system as a reabandonment.

A licensee must follow the requirements of Directive 059: *Energy Development Applications and Schedules* when re-entering an abandoned well for the purpose of production or if it is not the current licensee of the well.

3.4 Re-entry Wells

Wells that are re-entered must be abandoned in accordance with Directive 020 from the re-entry depth to surface. If there are abandoned zones below the re-entry depth, the requirements set out above for previous zonal abandonments (section 3.2) and leaking wells/forecasting casing stubs (section 3.3) apply.

4 Open-Hole Abandonment Requirements

For the abandonment of an open-hole well, the licensee must set cement plugs of sufficient length and number to

- cover all zones containing groundwater to the BGWP,
- cover all zones above the top of the Mannville Group (or equivalent, i.e., the Lower or Bluesky Groups or Spirit River Formation), and
- isolate or cover all porous zones below the top of the Mannville Group (or equivalent).

To determine the BGWP depth for a well, refer to the base of groundwater protection query tool available on the AER website, www.aer.ca, under Systems & Tools > Digital Data Submission > AER > Reports.

Porous zones are defined as

- carbonates with effective porosity greater than 1 per cent,
- sandstones with effective porosity greater than 3 per cent,
- a zone with offset production regardless of the porosity, or
- any zone with drillstem test formation fluid recoveries greater than 300 linear metres or gas volumes greater than 300 cubic metres.

4.1 Open-Hole Abandonment of Non-Oil Sands Wells

For wells that are not in an oil sands area (figure 1), the use of fillers and/or additives in the cement used for plugs is acceptable for open-hole abandonments if the compressive strength of the mixture is at least 3500 kPa after curing for 48 hours.

All zones above the top of the Mannville Group (or equivalent) must be covered with a plug that is placed in one or more stages.

- For wells where the top of the Wabamun Group (or equivalent) is at a depth less than 1500 m true vertical depth (TVD), this plug must extend a minimum of 17 vertical metres below the top of the Wabamun Group (or equivalent).
- For wells where the top of the Wabamun Group (or equivalent) is at a depth greater than 1500 m TVD, this plug must extend a minimum of 30 vertical metres below the top of the Wabamun Group (or equivalent).

Licensees must use the logs from the well to determine the exact plug placement for wells drilled deeper than the top of the Wabamun Group (or equivalent).

All plugs set at a depth less than 1500 m TVD must be a minimum length of 30 vertical metres, and they must extend a minimum of 17 vertical metres below and a minimum of 17 vertical metres above the zone being cemented.

All plugs set at a depth greater than 1500 m TVD must be a minimum length of 60 vertical metres, and they must extend a minimum of 30 vertical metres below and a minimum of 30 vertical metres above the zone being cemented.

A plug may extend over more than one zone.

Figure 4. Oil sands area boundary

Any plug may be staged; however, the fewer staged plugs in a wellbore, the more cost-effective a zone will most likely be. If a zone has

- a minimum distance between plugs as long as the pipe joint length, and
- a maximum distance between plugs as long as the maximum distance allowed by the regulatory requirements,

then the minimum number of plugs will be required.

The top plug must extend a minimum of 50 vertical metres above the casing shoe of the deepest casing set.

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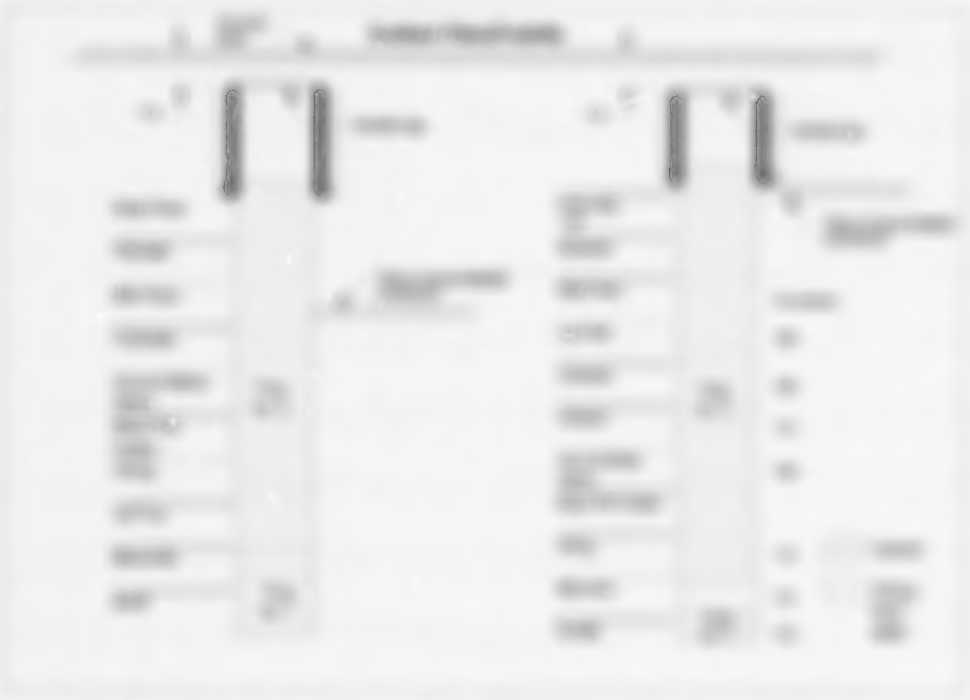

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Figure 4-36. [illegible]

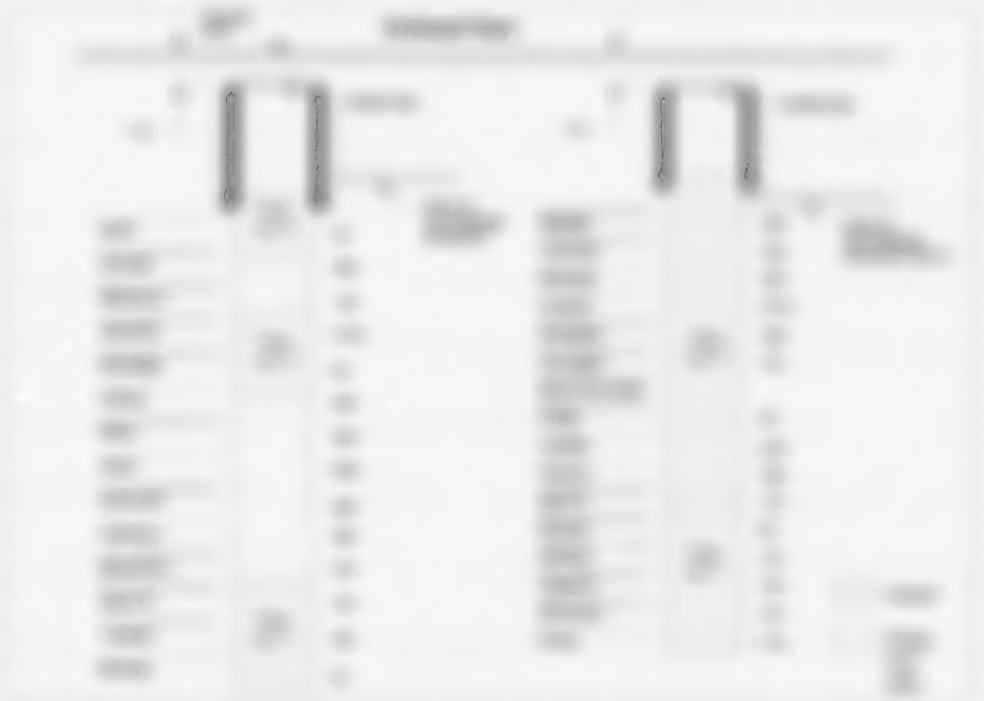

Figure 4-37. [illegible]

Figure 4.8 – Map of assessment coverage in the Intellectual Property

4.4.1 Subject Matter Interdependencies of Module / Topic Areas / Knowledge in Module Groups

The module groups are set out in the table below. Figure 1 – Subject Matter Interdependencies of Module Groups illustrates graphically the interdependencies between the module groups. Figure 2 – Module Interdependencies within Module Groups illustrates the interdependencies between the modules within each module group.

Table 4.8 – Module Groups

Module Group	Modules
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Athabasca Oil Sands Area

Township	Ranges
092–095	12W4M to 15W4M
087–091	09W4M to 15W4M
086	09W4M to 16W4M
085	02W4M to 17W4M
084	02W4M to 24W4M
083	04W4M to 24W4M
079–082	04W4M to 25W4M
078	04W4M to 22W4M
076–080	04W4M to 24W4M
085–087	01W4M to 24W4M
085–092	01W4M to 27W4M
093–100	01W4M to 26W4M
101–103	04W4M to 26W4M

Peace River Oil Sands Area

Township	Ranges
78–82	11W5M to 25W5M
83–87	11W5M to 24W5M
88–92	09W5M to 24W5M
93–95	07W5M to 17W5M

4.3 Wells in the Cold Lake/Athabasca Oil Sands Area

A thermal plug must be set from the well's total depth to a minimum of 15 vertical metres above the top of the Grand Rapids Formation.

All zones above the top of the Mannville Group (or equivalent) must be covered with a plug that is placed in one or more stages.

For intervals that are not across an oil sands zone, the use of fillers and/or additives in the cement is acceptable if the compressive strength of the mixture is at least 3500 kPa after curing for 48 hours.

Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and must not occur at a zone top.

The top plug must extend a minimum of 15 vertical metres above the casing shoe of the deepest casing set.

In a well in which intermediate casing has been set but has not been cemented full length, the uncemented interval must be evaluated as follows:

- If nonsaline groundwater has not been covered by surface casing and the intermediate casing cement top is below the BGWP, remedial cementing must be conducted to cover and/or isolate nonsaline groundwater.
- If there are porous intervals not covered by the intermediate casing's primary cement, remedial cementing must be conducted to cover/isolate the interval.

Following completion of the plugging program, the wellbore must be filled with nonsaline water.

An example plugging program is provided in figure 3.

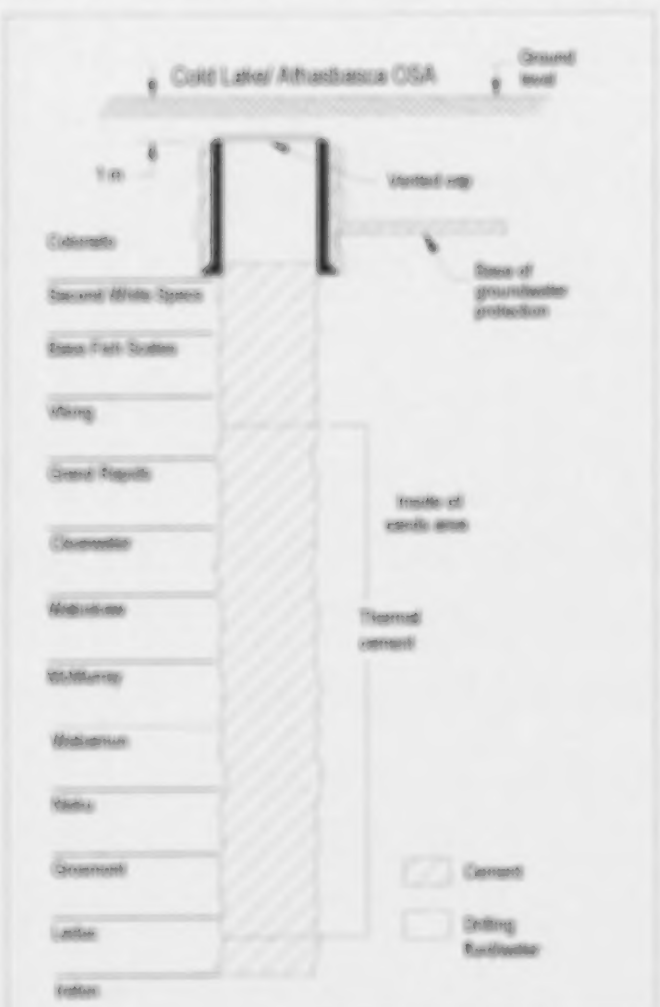

Figure 3. Plug placement example for Cold Lake/Athabasca Oil Sands Area

4.4 Wells in the Peace River Oil Sands Area

All zones above the top of the Spirit River Group must be covered with a plug that is placed in one or more stages. This plug must extend a minimum of 15 vertical metres below the top of the Spirit River Group.

Licensees must use the logs from the well to determine the exact plug placement for coverage and/or isolation of porous zones below the top of the Spirit River Group.

For intervals that are not across oil sands zones, the use of fillers and/or additives in the cement is acceptable if the compressive strength of the mixture is at least 3500 kPa after curing for 48 hours.

A thermal plug must be set that extends from a minimum of 15 vertical metres below the base of any oil sands zone to a minimum of 15 vertical metres above the top of the oil sands zone.

All plugs run at a depth less than 1500 m TVD must be a minimum length of 30 vertical metres, and they must extend a minimum of 15 vertical metres below and a minimum of 15 vertical metres above the zone being covered.

All plugs run at a depth greater than 1500 m TVD must be a minimum length of 60 vertical metres, and they must extend a minimum of 30 vertical metres below and a minimum of 30 vertical metres above the zone being covered.

A plug may extend over more than one zone.

Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and must not occur at a zone top.

There is no maximum distance between plugs as long as the pressure from the zone being isolated does not exceed the fracture pressure of the interval left open above it.

The top plug must extend a minimum of 15 vertical metres above the casing shoe of the deepest casing set.

In a well in which intermediate casing has been set but has not been cemented full length, the uncemented interval must be evaluated as follows:

- If nonsaline groundwater has not been covered by surface casing and the intermediate casing cement top is below the BGWP, remedial cementing must be conducted to cover and/or isolate nonsaline groundwater.
- If there are porous intervals not covered by the intermediate casing's primary cement, remedial cementing must be conducted to cover/isolate the interval.

Following completion of the plugging program, the wellbore must be filled with nonsaline water.

An example of a plugging program is provided in figure 4.

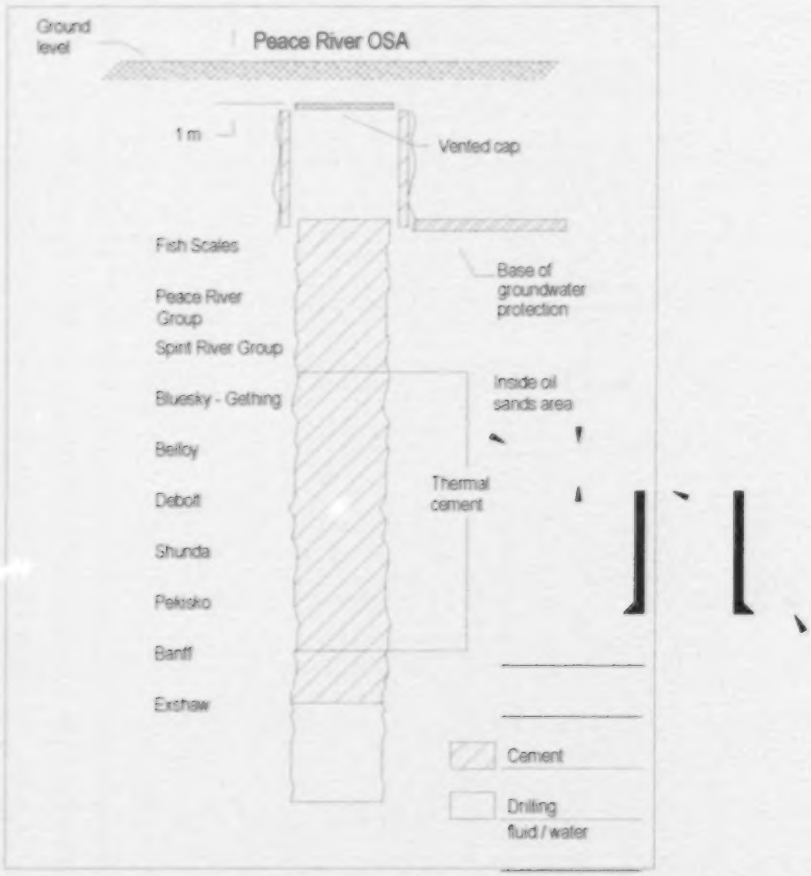

Figure 4. Plug placement example for Peace River Oil Sands Area

4.5 Confirming Plug Placement

The licensee must confirm the location of all plugs using one of the approved methods described in section 6. The only time a plug location does not have to be confirmed is if

- one stage of a multistage plug is placed, provided there is no loss of circulation;
- continuous cement is run from total depth to surface in one or more stages, provided there was no loss of circulation; or
- the top plug is placed, providing it is run to surface.

Plugs that are too low or too high or were misplaced are unacceptable (see figure 5).

The licensee must correct the misplaced plug and must confirm the new location.

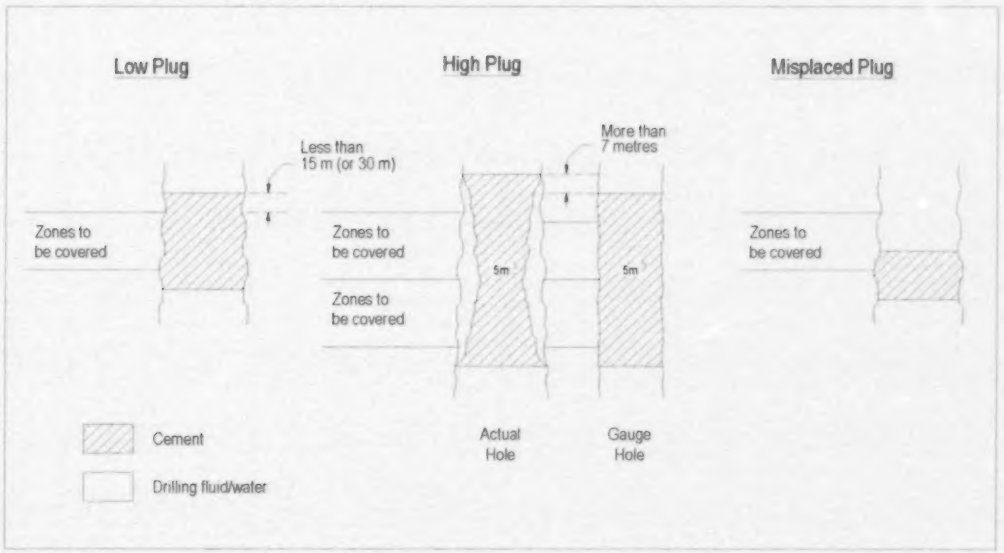

Figure 5. Unacceptable plugs

Regarding figure 5:

Plug is too low:

- For zones at a depth less than 1500 m TVD, a low plug is any plug with a top less than 15 vertical metres above the zone it was intended to cover.
- For zones at a depth greater than 1500 m TVD, a low plug is any plug with a top less than 30 vertical metres above the zone it was intended to cover.

Action required: Low plugs must be built up and then the new location must be confirmed.

Plug is too high: A plug that is located more than 7 vertical metres above its theoretical top is considered "high." To calculate a plug's theoretical top, use the formula

Actual cement volume (m^3)/gauge hole volume (m^3/m) = x m

Drill pipe setting depth (m) – x m = Theoretical top

Action required: High plugs must be circulated or drilled out. The plug must be rerun and its location confirmed.

Plug is misplaced: The plug was positioned in such a way that it did not cover the zone(s) it was intended to cover.

Action required: Depending on its position, a misplaced plug may first have to be circulated or drilled out. The plug must be rerun and its location confirmed.

4.6 Oil Sands Evaluation Wells and Test Hole Wells

Oil sands evaluation and test hole wells (as identified by "OV" and "TH" respectively on the licence's Lahee Classification) have specific abandonment requirements. These wells are drilled for core samples only and are not intended to be completed.

Downhole abandonment operations on oil sands evaluation and test hole wells in the surface mineable areas must be completed within 30 days after drilling has finished.

Downhole abandonment operations on oil sands evaluation and test hole wells that are outside of the surface mineable areas must be completed prior to rig release.

Oil sands evaluation and test hole wells that encounter an oil sands zone and/or are within a designated oil sands area must be filled with thermal cement from final total depth to surface.

Test hole wells that are drilled outside a designated oil sands area and do not encounter an oils sands zone must be filled with cement that has a final compressive strength of at least 3500 kPa after curing for 48 hours from final total depth to surface.

Any drop in cement due to pipe displacement must be replaced by an equivalent volume of nonsaline water. If the calculated and actual volumes required to fill the hole coincide, fluid level testing is not required.

Surface abandonment operations must be completed immediately after downhole operations.

Oil sands evaluation and test hole well abandonments are considered routine and must be reported within 30 days of completing the surface abandonment.

5 Cased-Hole Abandonment Requirements

In a cased-hole abandonment, the licensee must abandon each completed pool separately and cover all nonsaline groundwater with cement.

The abandonment program for a cased-hole well will depend on whether

- the well was completed,
- the well penetrated any oil sands zones, and
- the well has been completed in an interval that is classified as "level A."

For the purpose of this directive, level-A intervals are intervals that

- have been used for disposal of 1a or 1b fluids,
- have been used for injection of acid gas,

- have a hydrogen sulphide (H_2S) concentration in excess of 15 per cent, or
- have been designated as critical sour.

This evaluation is done on a well (not a pool) basis.

Note that it is advisable to perform testing prior to beginning downhole abandonment operations to avoid having to re-enter the well to correct a wellbore problem. Refer to section 7.

5.1 Cement Evaluation

The licensee must review the existing cement behind the casing string(s) of a well before beginning abandonment operations.

5.1.1 Cement Top Determination

The cement top can be determined by available locating log data, theoretical calculations, or a cement evaluation log. Confirmation of cement returns to surface in the drilling tour sheets during primary cementing is also acceptable for confirming cement coverage to surface.

A cement evaluation log must be run if

- theoretical calculations (using an excess of 20 per cent) indicate that the cement top does not extend a minimum of 15 vertical metres above the uppermost porous intervals, or
- there is a surface casing vent flow and/or gas migration issue present.

5.1.2 Identification of Porous Intervals

The licensee must identify porous zones (see glossary) and determine that hydraulic isolation exists between zones.

5.1.3 Remedial Cementing

If there are porous zones that are not isolated from each other, the licensee must perforate the casing and circulate cement to surface. If it is not possible to achieve circulation, cement squeeze(s) must be conducted to ensure isolation.

For remediation of surface casing vent flows or gas migration, see *ID 2003-01*.

5.2 Use of Inhibitor

The casing must be filled with nonsaline water from the uppermost abandoned zone (that is below the BGWP) to surface.

Inhibitor must not be used inside the casing over intervals that are above the BGWP.

For intervals below the BGWP that are isolated from the BGWP by an approved zonal abandonment method, the casing must be filled with either noncorrosive fluid or nonsaline water.

5.3 Wells Not Penetrating Oil Sands Zones

Requirements for abandonment operations on cased-hole wells that **do not** penetrate oil sands zones are as follows.

5.3.1 Noncompleted Wells

Noncompleted wells (without liners) do not require additional cement plugs to be run if the existing casing string is pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Noncompleted wells must be filled with nonsaline water.

5.3.2 Wells With a Cemented Liner

The completed interval must be abandoned in accordance with the requirements set out in sections 5.3.5, 5.3.6, or 5.3.7. Following abandonment of the completed interval(s), the licensee must use one of the following options for abandoning a liner top in a well with a cemented liner.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the liner top. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with either a minimum of 8 vertical metres of class "G" cement or with a minimum of 3 vertical metres of resin-based, low-permeability gypsum cement.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Plug

A cement plug must be set across the liner top. This plug must extend from a minimum of 15 vertical metres below the liner top to a minimum of 15 vertical metres above the liner top. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.3.3 Wells With an Uncemented Liner

To abandon a well with an uncemented liner across more than one zone, the zones behind the liner must be evaluated for porosity and a cement squeeze(s) must be conducted to ensure isolation between the porous zones.

Once the liner has been cemented, the requirements set out for abandonment of wells with a cemented liner (above) must be followed.

9.3.4 Wells With Casing Patching, Casing Failures, and Previously Cement Squeezed Intervals

For non-level A intervals, the licensee must use one of the following options for abandoning casing patches, casing failures (within one zone), and previously cement squeezed intervals (within one zone that have been drilled out). For abandonment of previously cement squeezed intervals that have been drilled out and are over more than one zone, each zone must be isolated by one of the methods below. For abandonment of casing failures that occur over more than one zone, a cement squeeze must be conducted as set out below in option 3.

Casing patches, casing failures, and previously cement squeezed intervals (that have been drilled out) that are over a level-A interval must be abandoned in accordance with section 9.3.5.1.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the interval. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with either a minimum of 5 vertical metres of class "G" cement or with a minimum of 3 vertical metres of room-based, low-permeability gypsum cement.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Plug/Squeezing Cement

A cement plug must be set that extends a minimum of 15 vertical metres below the bottom of the interval to a minimum 15 vertical metres above the top of the interval. The location of the plug must be confirmed by one of the approved methods described in section 4. The plug must be pressure tested to 7000 kPa for 10 minutes.

If the licensee elects to apply a squeeze pressure to the cement, the AER recommends following the criteria set out in Option 2 of section 9.3.5.1 (maximum cement volumes, final squeeze pressure, etc.).

9.3.5 Zonal Abandonment Within a Completed Well

9.3.5.1 Level-A Intervals

The licensee must use one of the following options for abandoning level-A intervals within a completed well.

Option 1—Setting a Cement Retainer

A cement retainer must be set within 15 m above the perforations or the single-zone open-hole section.

- The wellbore must be pressure tested to a stabilized pressure that equates to a minimum differential pressure of 7000 kPa for 10 minutes.
- A cement squeeze must be conducted through the perforations.
- The minimum cement volume must equal the casing volume from the bottom of the wellbore to the bottom perforation (or bottom of the open-hole section) plus 0.5 m^3.
- The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned.
- The wellbore must be capped with class "G" cement that is circulated in place and
  - is a minimum of 50 vertical metres in length,
  - extends a minimum of 50 vertical metres above the formation top, and
  - has a minimum volume of 1 m^3.

If the wellbore is drilled out, following drill-out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore.

At the time of well abandonment, the squeezed interval must be abandoned in accordance with section 9.3.5.1.

Option 2 – Squeezing Cement

A cement squeeze must be conducted into the perforations or the single-zone open-hole section.

The plug must

- be circulated in place,
- have a minimum volume of 1 m^3, and
- extend from a minimum of 15 vertical metres below the completion or total depth, whichever is shallowest, to a minimum of 50 vertical metres above the formation top.

The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

If this plug is to be drilled out, following drill-out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore. At the time of well abandonment, the squeezed intervals must be abandoned in accordance with section 9.3.5.1.

Option 1 – Setting a Permanent Bridge Plug

Abandonment of a branch is required by the earliest well activity once written approval from the AER (ID1.001) is received.

A bond log must be run over the interval where a permanent bridge plug will be set to a minimum of 50 m above the formation top. The bond log and log submission must be conducted in accordance with Directive 020, sections 7.1.4 and 7.1.5. If cased completion is confirmed, approval may be granted to set a permanent bridge plug within 15 m above the perforations or the single cross-open fluids section. Once the bridge plug has been set, it must be pressure tested to a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with Class "G" cement that is

- to a minimum of 50 vertical metres in length,
- extends a minimum of 50 vertical metres above the formation top, and
- has a minimum volume of 1 m^3.

If more than one cased has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again to a stabilized pressure of 7000 kPa for 10 minutes.

5.2.5.2 Non-Cased Intervals

The licensee must use one of the following options for abandoning non-cased intervals within a completed well:

Option 1 – Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the perforations or the single cross-open fluids section. Once the bridge plug has been set, it must be pressure tested to a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with either a minimum of 50 vertical metres of Class "G" cement or with a minimum of 7 vertical metres of cold-flowed, non-permeable, gypsum cement.

If more than one cased has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again to a stabilized pressure of 7000 kPa for 10 minutes.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option A — Setting a Custom Timezone

A custom timezone must be set within 1.5 hr after the confirmation of the single-use operation window. The timezone must be processed by a certified processor of 7000-0A list. A request to cancel a timezone must be confirmed as the confirmation of the single-use operation window. The timezone must be logged with a timestamp (UTC unless locale is later "D" unless. No 4MB incremental following the criteria set out in Option 1 of section 5.2.3.1 (unrelated custom timezone that approve processor, etc.).

If the timezone is verified via following verification, the approved record must be queued for 1 minutes in a validated processor capable of 7000-0A1 or 7F (go over of the operator or rejected must not proceed of the confirmation step until it signs in the software.

In the case of a UI disablement, the approved timezone must be deactivated in accordance with section 5.2.3.

Option B — Setting a Plug-in Processor Policy

A plug must be set in a prohibited applies 1 after 1.5 hr after the confirmation of the single-use operation window. The plug and policy must be processed by a validated processor of 7000-0A list. A timezone. The plug and policy must be logged with either a timestamp (UTC unless locale of other "D" unless) or a timestamp (UTC unless locale of underlayer) not permissible (custom unless).

If more than one user has logged from the setting and process configs of the plug and policy prior to logging with unless, the plug and policy must be processed again as a validated timezone of 7000-0A list. A timezone.

Option C — Setting a Custom Plug/Bypassing Custom

A custom plug must be set across the confirmation of the single-use operation window. The plug must be recorded timestamp (UTC unless locale) before the completed record of the plug must read legally. Window is no deployment (or a timestamp (UTC unless locale) where the copy of the completed record. It is acceptable to use a combination custom plug across multiple completed cases. The location of the plug must be confirmed for use of the approved workstation (unless). The plug must be processed by a validated processor of 7000-0A list. A timezone. If the location shown is again a approved processor in the console. Do 4MB incremental following the criteria set out in Option 1 of section 5.2.3.1 (unrelated custom timezone that approve processor, etc.).

If the custom plug is not be verified via, a custom approve must be unallowed. Following verification, the approved record must be processed by 1 timezone as a validated processor capable of the greater

of 7 KHZ-MA or CP type code of the current or expected most recent operator of the certificated object will be used in the software. (2) In the case of a CP disbelievement, the approved term of need for disbelievement is cancelled or modified under 7 U.S.C.

(1) (A) Completed Announced Fields or a Single Formatted

(1) (A) (i) Updated Code List

Permit disbelievement (1) (i) or (ii) does not relieve announced specimen data of the purchaser may terminate need for disbelievement with one of the following options:

Option (1) - Nothing or Cancel Shipment

If a permit requires need for use under 7 U.S.C. a fee of twenty dollars, the copy of the information is cancelled, terminated, or completed:

1. The violation need for a person covered by a certificate of purchase. When appeal of a commercial differential purpose of 7 KHZ-MA only. 7 U.S.C.
2. If a permit appeal or need for conditional through the violation:
   1. The commercial purpose violation does cancel the penalty criteria. Does the violation of the violation or the commercial need (apply of the 1 of 7 U.S.C.
   2. The shall appeal or purchase need for a commercial of 7 KHZ-MA after the violation does not purpose of the case being disbelieved.
3. The violation need for appeal with days "(A)" ____ fee is cancelled if a place said:
   1. In a commercial of "(1) critical" section or length; and
   2. Any commercial criteria of 7 U.S.

Option (2) - Approving Cancel

If a permit appeal need for conditional use the certificate or the single case specimen section.

The ruling must:

1. Be cancelled if a place;
2. Have a commercial criteria of 7 U.S. and
3. cancel if that act or failure the information age or commercial of "(1) critical reason data or the information may.

The shall appeal purpose need for a commercial of 7 KHZ-MA after the purpose case for purpose of the case being disbelieved. The location of the ruling must be confirmed for use of the appeal or a

[illegible] [illegible] [illegible] [

Option 2—Setting a Cement Retainer

A cement retainer must be set within 15 vertical metres above the top of the formation in which the horizontal zone is completed. The retainer must be pressure tested to a stabilized pressure of 7000 kPa for 10 minutes. A cement squeeze must be conducted through the retainer. The retainer must be capped with a minimum of 8 vertical metres of class "G" cement. The AER recommends following the criteria set out in Option 1 of section 5.3.6.1 (minimum cement volumes, final squeeze pressure, etc.).

Option 3—Setting a Cement Plug/Squeezing Cement

A cement squeeze must be conducted into the open-hole interval. The plug must extend from at or below the formation top to a minimum of 15 vertical metres above the formation top. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. If the licensee elects to apply a squeeze pressure to the cement, the AER recommends following the criteria set out in Option 2 of section 5.3.6.1 (minimum cement volumes, final squeeze pressure, etc.).

5.3.7 Completed Horizontal Wells Across Multiple Formations

For a horizontal open-hole interval that penetrates multiple formations, each porous formation must have a cement plug set in the open-hole section to either cover or isolate it from different porous formations. A minimum 30 vertical metre cement plug is required, extending either a minimum of 15 vertical metres below the formation or the plug-back total depth, whichever is shallower, to a minimum of 15 vertical metres above the porous formation. The location of the plug must be confirmed by one of the approved methods described in section 6.

If any of the horizontal intervals is a level-6 interval, the uppermost interval must be abandoned in accordance with section 5.3.6.1.

5.4 Wells Penetrating Oil Sands Zones

Requirements for abandonment operations on cased wells wells that are in an oil sands area (see figure 1) and penetrate oil sands zones are as follows.

5.4.1 Thermal Cement

Thermal cement must be used when abandoning wellbores that penetrate oil sands. Thermal cement is a blend that after curing for 48 hours has a minimum compressive strength of 2500 kPa at temperatures up to 360°C.

5.4.2 Noncompleted Wells

The casing string must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

All noncompleted oil sands zones must have a thermal cement plug run across the oil sands formation. The plug must extend from a minimum of 15 vertical metres below the formation or the plug-back total depth, whichever is shallower, to a minimum of 15 vertical metres above the top of the formation. This plug may be combined into a longer plug to cover two or more uncompleted oil sands zones. Nonsaline water must be used between plugs.

The location of suspended cement plugs must be confirmed by one of the approved methods described in section 6. The location of plugs that are run from plug back total depth (PBTD) to surface does not need to be confirmed.

Noncompleted wells with liners must have the liner abandoned in accordance with sections 5.4.3 or 5.4.4.

5.4.3 Wells With a Cemented Liner

The completed interval must be abandoned in accordance with the requirements set out below for completed, open-hole, or horizontal intervals (see section 5.4.6, 5.4.7, or 5.4.8). Following abandonment of the completed interval(s), the licensee must use one of the following options for abandoning a liner top in a well with a cemented liner.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the liner top. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with a minimum of 8 vertical metres of thermal cement.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Plug

A thermal cement plug must be set across the liner top. This plug must extend from a minimum of 15 vertical metres below the liner top to a minimum of 15 vertical metres above the liner top. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.4.4 Wells With an Uncemented Liner

To abandon a well with an uncemented liner across more than one zone, the zones behind the liner must be evaluated for porosity, and thermal cement squeeze(s) must be conducted to ensure isolation between the porous zones.

Once the liner has been cemented, the requirements set out for abandonment of wells with a cemented liner (section 5.4.3) must be followed.

5.4.5 Wells with Casing Patching, Casing Failures, and Previously Cement Squeezed Intervals

For non-level A intervals, the licensee must use one of the following options for abandoning casing patches, casing failures within one zone, and previously cement squeezed intervals within one zone that have been drilled out. For abandonment of previously cement squeezed intervals that have been drilled out and are over more than one zone, each zone must be isolated by one of the methods below. For abandonment of casing failures that occur over more than one zone, a cement squeeze must be conducted as set out below in option 2.

Casing patches, casing failures, and previously cement squeezed intervals (that have been drilled out) that are over a level-A interval must be abandoned in accordance with section 5.4.6.1.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the interval. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with a minimum of 8 vertical metres of thermal cement.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Plug /Squeezing Cement

A thermal cement plug must be set that extends a minimum of 15 vertical metres below the bottom of the interval to a minimum 15 vertical metres above the top of the interval. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. If the licensee elects to apply a squeeze pressure to the cement, the AER recommends following the criteria set out in Option 2 of section 5.4.6.1 (minimum cement volumes, final squeeze pressures, etc.).

5.4.6 Completed Wells

The licensee must review the well logs to determine which oil sands zones have been penetrated by the well.

Oil sands zones that have been penetrated but not completed must have a thermal cement plug run in accordance with section 5.4.2.

Each oil sands zone that is completed must be abandoned using one of the following options.

5.4.6.1 Level-A Intervals

The licensee must use one of the following options for abandoning level-A intervals within a completed well.

Option 1—Setting a Cement Retainer

A cement retainer must be set within 15 m above the perforations or the single-zone open-hole section.

- The retainer must be pressure tested to a stabilized pressure that equates to a minimum differential pressure of 7000 kPa for 10 minutes.
- A thermal cement squeeze must be conducted through the retainer.
- The minimum cement volume must equal the casing volume from the bottom of the retainer to the bottom perforation (or bottom of the open-hole section) plus 0.5 m^3.
- The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned.
- The retainer must be capped with thermal cement that is circulated in place and
  - is a minimum of 30 vertical metres in length,
  - extends a minimum of 30 vertical metres above the formation top, and
  - has a minimum volume of 1 m^3.

If the retainer is drilled out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore.

At the time of well abandonment, the squeezed interval(s) must be abandoned in accordance with section 5.4.6.1.

Option 2—Squeezing Cement

A thermal cement squeeze must be conducted into the perforations or the single-zone open-hole section.

The plug must

- be circulated in place,
- have a minimum volume of 1 m^3, and
- extend from a minimum of 15 vertical metres below the completion or total depth, whichever is shallower, to a minimum of 30 vertical metres above the formation top.

The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

If this plug is to be drilled out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore. At the time of well abandonment, the squeezed intervals must be abandoned in accordance with section 5.3.5.1.

Option 3—Setting a Permanent Bridge Plug

Abandonment of a Level-A interval by this method will require nonroutine approval from the AER (WellOperations@aer.ca).

A bond log must be run over the interval where a permanent bridge plug will be set to a minimum of 60 m above the formation top. The bond log and the log interpretation must be submitted in accordance with *Directive 080*, sections 7.6 and 7.7. If zonal isolation is confirmed, approval may be granted to set a permanent bridge plug within 15 m above the perforation or the single-zone open-hole section. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with thermal cement that is circulated in place and

- is a minimum of 60 vertical metres in length,
- extends a minimum of 60 vertical metres above the formation top, and
- has a minimum volume of 1 m^3.

If more than one year has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again at a stabilized pressure of 7000 kPa for 10 minutes.

5.4.6.2 Non-Level-A Intervals

The licensee must use one of the following options for abandoning non-level-A intervals within a completed well.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 m above the perforations or the single-zone open-hole section. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with a minimum of 8 vertical metres of thermal cement. The cement top must extend a minimum of 15 vertical metres above the formation top.

If more than one year has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again at a stabilized pressure of 7000 kPa for 10 minutes.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Retainer

A cement retainer must be set within 15 m above the perforations or the single-zone open-hole section. The retainer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. A thermal cement squeeze must be conducted into the perforations or the single-zone open-hole section. The retainer must be capped with a minimum of 8 vertical metres of thermal cement. The cement top must extend a minimum of 15 vertical metres above the formation top. The AER recommends following the criteria set out in Option 1 of section 5.4.6.1 (minimum cement volumes, final squeeze pressures, etc.).

If this plug is to be drilled out, following drill-out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore. At the time of well abandonment, the squeezed intervals must be abandoned in accordance with section 5.4.5.

Option 3—Setting a Plug in a Permanent Packer

A plug must be set in a permanent packer within 15 m above the perforation or the single-zone open-hole section. The plug and packer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with a minimum of 8 vertical metres of thermal cement. The cement top must extend a minimum of 15 vertical metres above the formation top.

If more than one year has elapsed from the setting and pressure testing of the plug and packer prior to capping with cement, the plug and packer must be pressure tested again at a stabilized pressure of 7000 kPa for 10 minutes.

Option 4—Setting a Cement Plug/Squeezing Cement

A thermal cement plug must be set across the perforations or the single-zone open-hole section. The plug must extend a minimum of 15 vertical metres below either the completed interval or the plug-back total depth, whichever is shallower, to a minimum of 15 vertical metres above the top of the formation. It is acceptable to run a continuous thermal cement plug across multiple zones. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. If the licensee elects to apply a squeeze pressure to the cement, the AER recommends following the criteria set out in Option 2 of section 5.4.6.1 (minimum cement volumes, final squeeze pressures, etc.).

If the cement plug is to be drilled out, a cement squeeze must be conducted. Following drill-out, the squeezed interval must be pressure tested for 10 minutes at a stabilized pressure equal to the greater of 7000 kPa or 85 per cent of the current or expected reservoir pressure of the perforations that will be open to the wellbore. At the time of well abandonment, the squeezed interval must be abandoned in accordance with section 5.4.5.

5.4.7 Completed Horizontal Wells in a Single Formation

5.4.7.1 Level-A Intervals

Zonal abandonment of a level-A interval with a horizontal open-hole interval that penetrates one formation must be abandoned with one of the following options.

Option 1—Setting a Cement Retainer

A cement retainer must be set within 15 vertical metres above the top of the formation in which the horizontal zone is completed.

- The retainer must be pressure tested to a stabilized pressure that equates to a minimum differential pressure of 7000 kPa for 10 minutes.
- A thermal cement squeeze must be conducted through the retainer.
  - The minimum cement volume must equal the casing volume from the bottom of the retainer to the measured total depth of the well plus 0.5 m^3.
  - The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned.
- The retainer must be capped with thermal cement that is circulated in place and
  - is a minimum of 30 vertical metres in length, and
  - has a minimum volume of 1 m^3.

Option 2—Squeezing Cement

A thermal cement squeeze must be conducted into the perforations or the single-zone open-hole section.

The plug must

- be circulated in place,
- have a minimum volume of 1 m^3, and
- extend from at or below the formation top to a minimum of 30 vertical metres above the formation top.

The final squeeze pressure must be a minimum of 7000 kPa above the current reservoir pressure of the zone being abandoned. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Option 3—Setting a Permanent Bridge Plug

Abandonment of a Level-A interval by this method will require concurrence approval from the AER (WellOperations@aer.ca).

A bond log must be run over the interval where a permanent bridge plug will be set to a minimum of 60 m above the formation top. The bond log and the log interpretation must be submitted in accordance with *Directive 080*, sections 7.6 and 7.7. If zonal isolation is confirmed, approval may be granted to set a permanent bridge within 15 vertical metres above the top of the formation in which the horizontal zone is completed. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with thermal cement that is circulated in place and

- is a minimum of 60 vertical metres in length,
- is a minimum of 60 vertical metres above the formation top, and
- has a minimum volume of 1 m^3.

If more than one year has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again at a stabilized pressure of 7000 kPa for 10 minutes.

5.4.7.2 Non-Level-A Intervals

Zonal abandonment of a non-level-A horizontal open-hole interval that penetrates one formation must be abandoned with one of the following options.

Option 1—Setting a Permanent Bridge Plug

A permanent bridge plug must be set within 15 vertical metres above the top of the formation in which the horizontal zone is completed. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with a minimum of 8 vertical metres of thermal cement. The cement top must extend a minimum of 15 vertical metres above the formation top.

If more than one year has elapsed from the setting and pressure testing of the bridge plug prior to capping with cement, the bridge plug must be pressure tested again at a stabilized pressure of 7000 kPa for 10 minutes.

A retainer that has not been activated can be substituted for the permanent bridge plug.

Option 2—Setting a Cement Retainer

A cement retainer must be set within 15 vertical metres above the top of the formation in which the horizontal zone is completed. The retainer must be pressure tested to a stabilized pressure of 7000 kPa for 10 minutes. A thermal cement squeeze must be conducted through the retainer. The retainer must be capped with a minimum of 8 vertical metres of thermal cement. The cement top must extend a minimum of 15 vertical metres above the formation top. The AER recommends following the criteria set out in Option 1 of section 5.4.7.1 (minimum cement volumes, final squeeze pressures, etc.).

Option 3—Setting a Cement Plug/Squeezing Cement

A thermal cement squeeze must be conducted into the open-hole interval. The plug must extend from at or below the formation top to a minimum of 15 vertical metres above the formation top. The location of the plug must be confirmed by one of the approved methods described in section 6. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. If the licensee elects to apply a squeeze pressure to the cement, the AER recommends following the criteria set out in Option 2 of section 5.4.7.1 (minimum cement volumes, final squeeze pressures, etc.).

5.4.9 Completed Horizontal Wells Across Multiple Formations

For a horizontal open-hole interval that penetrates multiple formations, each porous formation must have a thermal cement plug set in the open-hole section to either cover or isolate it from different porous formations. A minimum 30 vertical metre thermal cement plug is required, extending either a minimum of 15 vertical metres below the formation or the plug-back total depth, whichever is shallower, to a minimum of 15 vertical metres above the porous formation. The location of the plug must be confirmed by one of the approved methods described in section 6.

If any of the horizontal intervals is a level-A interval, the uppermost interval must be abandoned in accordance with section 5.4.7.1.

5.5 Groundwater Protection

All nonsaline groundwater must be covered by cement. Groundwater protection must include the identification and isolation of the BGWP from hydrocarbon formations below, as well as the identification and isolation of all protected intervals that are above the BGWP.

To determine the BGWP depth for a well, the licensee must refer to the base of groundwater protection query tool available on the AER website, www.aer.ca, under Systems & Tools > Digital Data Submission > AER > Reports. The elevations provided are subsea and must be converted to kelly bushing (KB).

A protected interval is an interval that is above the BUWP and is defined as:

- any lithology with greater than 7 per cent porosity, or
- any coal seam.

Protected intervals may be grouped together (i.e., not isolated), provided that:

- the lithologies with greater than 7 per cent porosity are not separated from each other by more than 30 m, and
- the coal seams are not separated by:
  - more than 70 m of non-coal-bearing strata, or
  - a sandstone bed with greater than 7 per cent porosity.

5.5.1 Permanent Cementing of Protected Intervals

The licensee must use one of the following options to cover or isolate all protected intervals:

Option 1 — Removing Casing and Setting a Cement Plug

Prior to pulling the casing, all downhole abandonment operations must be completed in accordance with *Directive 020* or any succeeding approval that may be in place.

If the casing is free below the BUWP, the licensee may cut and pull the casing. Casing removal schemes that meet the following requirements are exempt. Any casing string other than the surface casing may be removed.

The cut point must be identified at or below the BUWP.

A permanent bridge plug must be set a minimum of 17 m below the intended cut point.

The bridge plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

The casing must be cut at the cut point identified.

Once the casing is cut and pulled, a cement plug must be set from the bridge plug to a minimum of 17 m above the surface casing shoe.

The cement plug must be located and pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

If the casing is unsuccessfully recovered, the AER (*[illegible]*) must be contacted.

Option 3 – Perforating, Milling, or Working Casing

The licensee must perforate, mill, or slot the casing at the [illegible] and attempt to establish circulation to the surface with remaining water. A maximum of [illegible] of cement may be used to establish circulation.

9.8.1.1 Circulation to Surface Successful

If circulation to surface is successful, the licensee must gauge cement to surface by either setting a cement retainer above the perforations or the milled or slotted casing or by circulating cement to surface and leaving a cement plug across the perforations, milled, or slotted casing.

- If a retainer is used, the cement retainer must be set within [illegible] of above the perforations or the milled or slotted casing. The retainer must be pressure tested to a stabilized pressure of [illegible] psi for [illegible] minutes. Following pumping of cement, the retainer must be capped with a minimum of [illegible] vertical metres of class 'G' cement.
- If a retainer is not used, a bridge or wiper plug must be set as close as possible below the perforations or the milled or slotted casing. The cement slurry inside the casing must be a minimum of [illegible] vertical metres above the perforations or the milled or slotted casing. The location of the plug must be confirmed by one of the approved methods described in section [illegible]. The plug must be pressure tested to a stabilized pressure of [illegible] psi for [illegible] minutes.

9.8.1.2 Circulation to Surface Unsuccessful

If circulation to surface is unsuccessful, the licensee must attempt to establish a local rate. If a local rate can be established, cement must be squeezed in behind according the formation fracture pressure into the perforations or the milled or slotted casing.

- If a retainer is used for the above operations, the cement retainer must be set within [illegible] of above the perforations or the milled or slotted casing. The retainer must be pressure tested to a stabilized pressure of [illegible] psi for [illegible] minutes. The retainer must be capped with a minimum of [illegible] vertical metres of class 'G' cement.
- If a retainer is not used for the above operations, a cement plug must be set from a minimum of [illegible] vertical metres below the perforations or the milled or slotted casing to a maximum of [illegible] vertical metres above the perforations or the milled or slotted casing. The location of the plug must be confirmed by one of the approved methods described in section [illegible]. The plug must be pressure tested to a stabilized pressure of [illegible] psi for [illegible] minutes.

If a local rate is unsuccessful, the perforations must be abandoned in accordance with one of the options set out in section [illegible].

The licensee must have a valid tachograph card of the driver and must not allow the tachograph card to be withdrawn from such driver.

3.3.2.2 Requesting or Downloading Protected Vehicle Data

The VDR supports data protection and must be accessed by authorised personnel only. In specific circumstances, the VDR may provide indirect support to requests for unprotected vehicle data. Detailed procedures for which a prosecution request is supported are unavailable.

In order to access protected data, the requesting authority must be established by the licensee and authorised by the VDR as per 3.3.2.2(a) to (d) below.

The written procedure must include:

a. the method of identifying authorised requesting staff;

b. the procedure for verifying a request and handling of identifications;

c. the VDR API; and

d. confirmation that a qualified tachographer of the licensee is present when the protected data is accessed and the vehicle owning undertaking is notified.

A request for a prosecution protection must be made to the appropriate VDR prior to beginning any work.

3.4 Confirming Location of Tachograph Plugs

3.4.1 Methods for Confirming Plug Location

There are three VDR approved methods for confirming the location of plugs. Method 1 is the preferred method. If Methods 2, 3 or 4 are used, care must be taken to ensure that the correct plug is used "wrong way".

Method 1 – Confirmation of Plug Location with VDR Plug

This method uses a setup utility – accessing and counting pulses of GNSS data – and subsequent VDR adjustment to determine the GNSS data and log depth for each plug and the location of the plug cap.

The location of the plug cap must not be confirmed until after 4 hours from the time the plug was last in other vehicle sockets have run. The minimum hours under which plugs must be located is 1000 driven hours or driving in split, whichever is less.

Note that the use of third party or workflow is not an approved plug cap locating method.

The Licensee or an Interested Party following a dispute or the issue of a good

- [illegible] a gas, steam, [illegible] and [illegible] a [illegible] or [illegible] [illegible] [illegible]
- [illegible] a [illegible] [illegible] [illegible]

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Item	Description	Value
A-01	Lorem ipsum dolor sit amet	1,250
A-02	Consectetur adipiscing elit	3,400
A-03	Sed do eiusmod tempor	875
A-04	Incididunt ut labore et dolore	2,100
A-05	Magna aliqua ut enim ad minim	560

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The licensee must submit the following information with the plug log:

- mud density and bit size,
- interval to be cemented,
- drill pipe setting depth (strap tally and adjustments used in conjunction with the collar locator must be included to support the drill pipe setting depth),
- mass in tonnes and volume in cubic metres of cement that was run during placement of the plug (this includes the calculated volume plus any excess run),
- type/class of cement used, including any additives and the average slurry density,
- volume of displacement fluid used,
- plug placement time and logging time,
- interval logged,
- depth at which the cement top was logged,
- quality of cement samples (this is a visual analysis usually conducted by the cementing company; the analysis consists of time required for samples to set at surface), and
- a trace of the base correlation log shown on the plug log or remarks for all gamma ray deflections that were visually correlated and any depth corrections made.

7 Testing and Inspection Requirements

Before beginning any surface abandonment operation, the licensee must perform certain required tests on the well, as detailed below.

It is advisable to perform the gas migration and surface casing vent flow tests prior to beginning downhole abandonment operations to avoid having to re-enter the well to correct a wellbore problem. If testing indicates the presence of gas migration (GM), a surface casing vent flow (SCVF) or a leaking plug(s), the source of the leak must be identified and repaired prior to surface abandonment.

7.1 Gas Migration Testing for Open- and Cased-Hole Wells

7.1.1 Gas Migration Test Area

GM testing must be conducted on cased-hole well abandonments where the well does not have a surface casing vent assembly and on all wells that are located in the required test area (see figure 6).

The required test areas are

- Townships 45–52, Ranges 1–9, W4M, and
- Townships 53–62, Ranges 4–17, W4M.

To reduce the chance of re-entering a well for repair, the AER recommends that all wells be tested for GM prior to abandonment. See appendix 2 for a suggested method of GM testing.

7.1.2 Notification of Gas Migration

If a GM problem is detected, the licensee must notify the AER through the DDS system (System & Tools > Digital Data Submission > AER > Incidents > Surface Casing Vent Flow/Gas Migration) within 30 days of detection. See *IL 2003-01* for definitions of serious and non-serious GM.

If GM is discovered *after* surface abandonment has been completed on a well, the licensee must notify the AER through the DDS system (System & Tools > Digital Data Submission > AER > Incidents > Surface Casing Vent Flow/Gas Migration) within 30 days of detection.

The licensee is required to repair the GM and must obtain a nonroutine abandonment approval prior to re-entering and reabandoning the well.

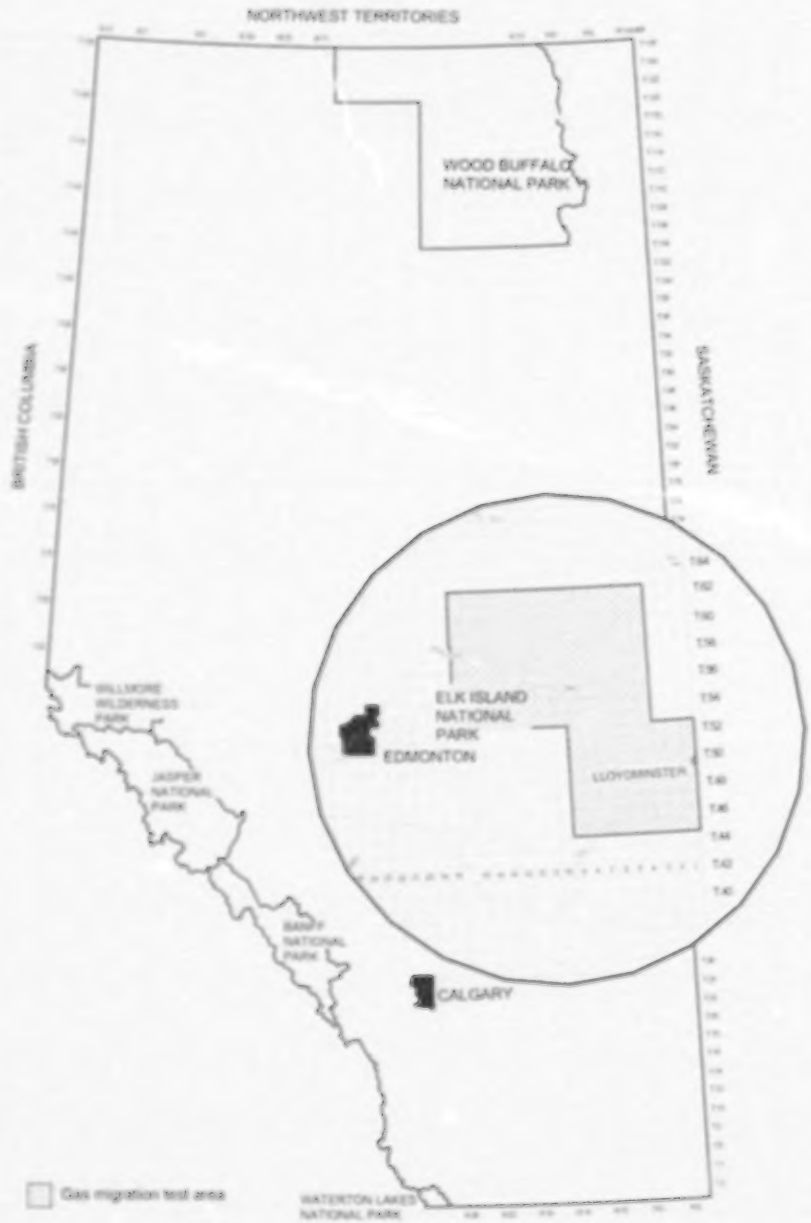

Figure 6. Gas migration test area

7.2 Fluid Level Test for Open-Hole Wells

Prior to conducting a surface abandonment, the licensee must conduct a **fluid level test** to determine if there are any leaking plugs. The fluid level test must be performed a minimum of 5 days after downhole abandonment operations have been completed. To perform the test, the licensee must visually inspect the well to ensure that the fluid level inside the casing is static and there are no gas bubbles present. In the event of a leaking plug, the licensee must prepare a reabandonment program and submit a nonroutine abandonment request via the DDS system (AER > Submissions > Licence Abandonment > Non-routine Well Abandonment) within 30 days of discovery of the leaking plug.

Fluid level testing is not required for oil sands evaluation and test hole wells where the fluid required to fill the hole coincided with the calculated pipe displacement volume (see section 4.6).

If a well is in the designated site inspection region (figure 7), the licensee must wait until the well passes an AER site inspection before cutting and capping the well. To schedule a site inspection, the licensee must contact the AER Medicine Hat Field Centre at 403-527-3385 within 24 hours after conducting downhole abandonment operations. The licensee must provide the well location, company contact name and phone number. The Medicine Hat Field Centre will arrange a site inspection of the well.

The site inspection region includes

- Townships 7–14, Ranges 12–17, W4M, and
- Townships 15–18, Ranges 10–13, W4M.

Until the well has been inspected, the surface casing must be left open, with fluid visible and protected from freezing. The well will be visually inspected by AER staff for leaking plugs and the results communicated to the licensee.

7.3 Surface Casing Vent Flow Test for Cased-Hole Wells

Prior to conducting a surface abandonment, the licensee must conduct a **surface casing vent flow test** to determine if gas, liquid, or any combination of substances is escaping from the casing vent assembly.

A bubble test must be conducted with a hose 2.5 cm below the water surface for a minimum of 10 minutes. If any bubbles are present during the 10-minute test, the well has a vent flow.

7.3.1 Rate Determination

If bubbles were present during the bubble test, a SCVF rate test must be conducted. This test should be continued until a stabilized rate is obtained.

The licensee must use either a positive displacement gas metre or an orifice well tester to measure vented gas volumes.

7.3.2 Determination of Stabilized Shut-in Surface Casing Pressure

If bubbles were present during the bubble test, the SCV must be shut in until a stabilized pressure is obtained. The pressure is considered stabilized if the change in pressure is less than 2 kPa/hr over a six-hour period.

7.3.3 Determination of Serious or Non-Serious Vent Flow

The licensee must determine if the vent flow is serious or non-serious in accordance with the criteria set out in *ID 2003-01*.

7.3.4 Notification of SCVF

If any bubbles were present during the 10-minute SCVF test, the licensee must notify the AER via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection and repaired in accordance with *ID 2003-01*.

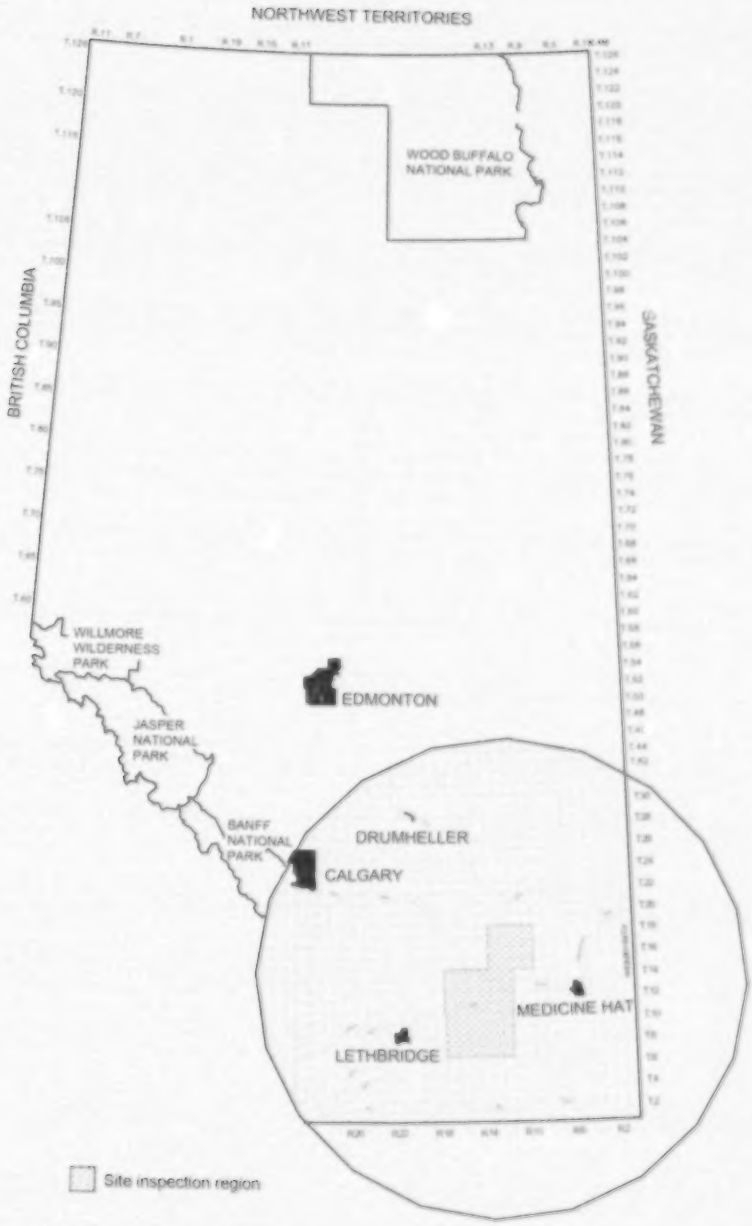

Figure 7. Site inspection region

8 Surface Abandonment

Surface abandonment is the cutting off of casing string(s) and the capping of a well.

The licensee must not begin surface abandonment until the required testing (see section 7) has been performed and the test results indicate the absence of any wellbore problem.

Surface abandonment must be completed within 12 months after downhole abandonment operations.

If the well is being abandoned due to an order of the AER, the licensee must begin surface abandonment as directed.

The licensee must inform all affected parties, including the landowner and/or occupant, of a planned surface abandonment before beginning any work.

Surface abandonment must be reported through the DDS system (AER > Submissions > Licence Abandonment > Well Licence Abandonment) within 30 days of completing the operation.

Surface equipment, cement pads, debris, and produced liquids associated with the well licence must be removed within 12 months of the cutting and capping operation.

The licensee must retain the record of the removal and cleanup activities and make this available to the AER upon request.

8.1 Cutting and Capping

The casing string(s) must be cut off a minimum of 1 m below the final contour elevation, with the following exceptions:

- If the well is in an area with special farming practices, such as deep tillage, drainage works, or peat lands, or is within 15 km of an urban development, the casing string(s) must be cut off a minimum of 2 m below final contour elevation.

If the well is located in an area where surface mining will be conducted,

- a cement plug must be circulated from the uppermost abandonment plug to 15 m below the intended strip mining depth, and
- above the strip mining depth, the casing must be cut at intervals agreed upon by the mining operator.

Surface, intermediate, and production casing strings must be capped at surface with a steel plate that is fastened and installed in a manner as to prevent any potential for pressure to build up within the casings while restricting access to the casing strings at surface.

Note that the "wedding cake" style cut and cap is now permitted.

The licensee must retain the record of the capping and venting procedure used in the well file for the life of the well. The documentation must be made available to the AER upon request.

Typical cased-hole abandonment schematics are shown in figures 8 and 9.

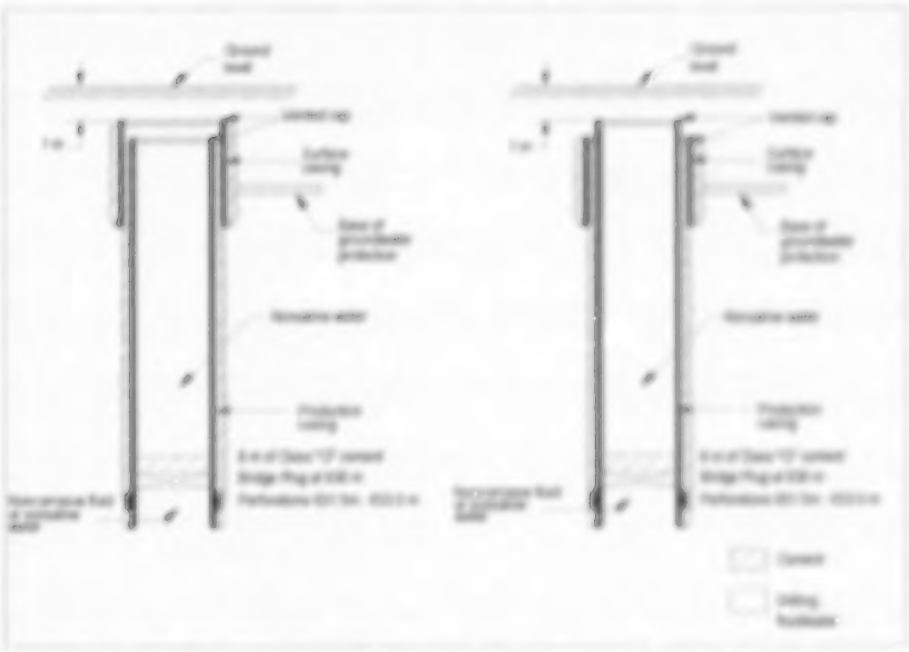

Figure 8. Examples of cased-hole abandonment for non-level-A intervals

Figure 6. Examples of cased hole abandonment for Level 4 intervals

Appendix 1 Definitions for the Purposes of Directive 020

Cased-hole well abandonment	The downhole abandonment of a completed or cased well
In situ coal gasification/liquefaction	The monitored thermal or chemical conversion of coal into synthetic coal gas or liquid in an underground seam
Level 4 interval	For the purpose of this directive, level 4 intervals are intervals that • have been used for disposal of 1a or 1b fluids, • have been used for injection of acid gas, • have an H_2S concentration in excess of 1% per cent, or • have been designated as critical sour. This evaluation is done on a well (not a pool) basis.
Mannville Group equivalent	The comparable geological formation to the Mannville, such as the Lower or Mannville Groups or Spirit River Formation
Non-completed well	A well that has not been perforated and has no open-hole section
Non-saline water	Water that has total dissolved solids less than or equal to 4000 milligrams per litre
Open-hole well abandonment	The downhole abandonment of an open-hole well after drilling is complete but before the rig is released
Plug back	The downhole abandonment of a portion of an open-hole well
Porous zone	A zone that • has carbonates with effective porosity greater than 1 per cent, • has sandstones with effective porosity greater than 1 per cent, • has offset production, regardless of its porosity, or • has drillstem test formation fluid recoveries greater than 100 linear metres or gas volumes greater than 100 cubic metres
Protected interval	• Any lithology with greater than 1 per cent porosity • Any coal seam
Remedial cementing	Cementing operations performed to repair primary cementing problems or to treat conditions arising after the wellbore has been constructed
Surface abandonment	The cutting off of casing strings and the capping of a well
Thermal cement	A cement blend that after curing for 48 hours has a minimum compressive strength of 1500 kPa at a temperature of 300°C

[illegible]	[illegible]
[illegible]	[illegible]

Appendix G — Suggested Procedure for Gas Regulator Testing

This is a safe, basic way to test a gas regulator. It uses a pressure gauge and a controlled gas source. Always follow your school's rules and your teacher's instructions. Never test a gas regulator on a real gas line unless you are trained and supervised.

Before you start, make sure you have the right safety gear. Wear safety glasses. Work in a well-ventilated area. Keep flames and sparks far away. Have a fire extinguisher nearby. If you smell gas at any point, stop the test and open windows.

You will need a regulator, a pressure gauge, a gas source (like a small cylinder), tubing, and fittings to connect them. Check that the gauge can read the pressure you expect. Check that the tubing is rated for gas use.

Connect the gauge to the outlet side of the regulator. Make sure the connections are tight. Connect the gas source to the inlet side. Open the gas source slowly. Watch the gauge as you do this.

Set the regulator to its lowest setting. Then slowly turn the adjustment screw to raise the pressure. Stop at the pressure you want to test. Do not go above the regulator's rated maximum.

Hold the pressure steady for a few minutes. Watch the gauge. If the pressure drops, there may be a leak. Close the gas source and check all connections with soapy water. Bubbles will show where gas is escaping.

Release the pressure by opening a downstream valve or bleeding the line. Close the gas source when you are done. Record your results, including the pressure you tested and whether you found any leaks.

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Appendix A2 — Suggested Procedure for Sterilizer Loading and Post-Loading

Refer to the OEM's detailed instructions for use. Only validated processes may be used. Load the sterilizer as described during the validation. Do not overload the chamber. Ensure adequate space between packages for steam circulation. Do not stack packages directly on the chamber floor. Use the shelves provided.

Before Use

Environmental Requirements

- Ambient temperature between 18°C and 40°C
- Water supply (distilled water recommended) is connected, and the water tank is filled to the indicated level
- Power supply is stable and the sterilizer is connected to a properly grounded outlet

Loading Procedure

- Ensure the door is closed and locked
- Ensure the drain is closed
- Connect the filling hose and open the water supply valve
- Remove any accessories and load the sterilizer with the packages
- Close the door and lock it
- Select the appropriate program for the load
- Start the cycle

Post-Sterilization

Unload the sterilizer when the cycle is complete. Use heat-resistant gloves to avoid burns. Allow the packages to cool before handling. Inspect the packages for any signs of damage or contamination. Do not use packages that appear compromised.

The following are some recommended practices for maintaining a sterilizer in good working condition:

- Clean the chamber and shelves regularly
- Replace the water filter as needed
- Keep a maintenance log to track usage and any issues

Determination of Stabilized Shut-in Surface Casing Pressure

Recommended Equipment

- pressure gauge or single pen static pressure recorder
- pressure relief valve calibrated to release at a pressure equal to 11 kPa/m × length of surface casing setting depth (m)

Testing Procedures

- Install pressure recorder or pressure gauge and pressure relief valve.
- Ensure that there are no gas leaks at fittings and welds.
- If a chart is used:
  - If pressure has not stabilized, it will be necessary to change the recorder to cover a longer time period in order to achieve a maximum shut-in pressure. Repeat the first two steps.
  - If chart pressure reaches the maximum pressure relief valve setting, record result.
  - If chart pressure stabilizes and is below pressure relief valve setting, record result.
- If a pressure gauge is used, monitor the readings to determine when a stabilized maximum pressure is obtained and record this value.
  - If gauge pressure reaches the maximum pressure relief valve setting, record result.
- Remove equipment and leave casing venting.